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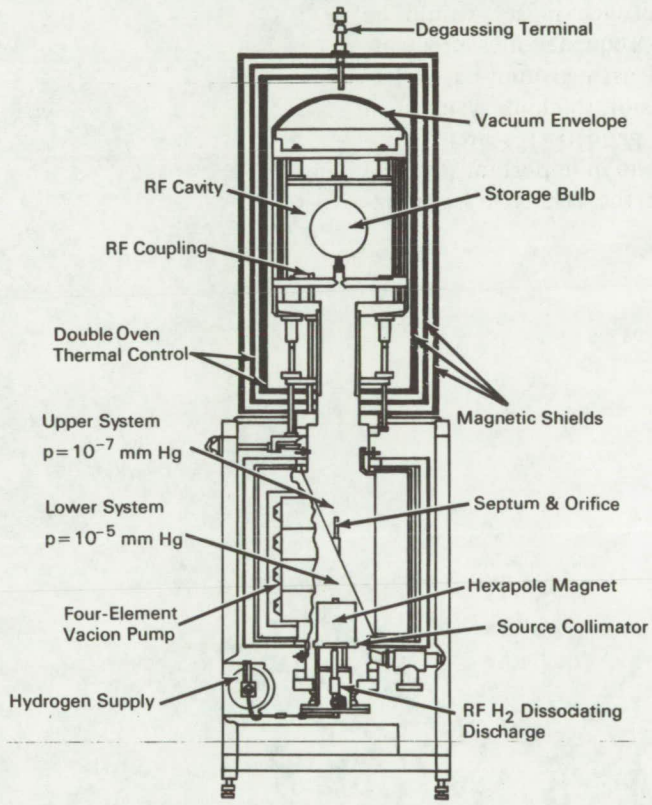
# NASA TECH BRIEF



## Hydrogen Maser as a Highly Stable Frequency Reference




Tracking, communication, and guidance requirements for the launch, earth orbital, and deep space phases of a mission often demand frequency sources having a very high order of short- and long-term frequency stability, as well as a high degree of intrinsic reproducibility. In 1961, NASA's Manned Space Flight Center began a search for such a frequency source and found that the hydrogen maser, invented by Dr. Norman Ramsey of Harvard University, showed excellent promise of providing the desired characteristics. A research and development project was therefore begun under contract to improve the basic hydrogen maser for use as a highly stable frequency reference for precision tracking systems.

The hydrogen maser illustrated in the schematic diagram represents the first step in achieving an overall reduction in size. This unit is 56 centimeters square at the base, 200 centimeters high, and weighs approximately 360 kilograms.

The short- and long-term frequency stability and the resettability, expressed as the rms deviation from the mean, for the maser, which has a nominal resonance

(continued overleaf)

frequency of 1420.405751 MHz, is listed below:

| | |
|---|---|
| 1 second | $5\times10^{-13}$ |
| 1 minute | $6\times10^{-14}$ |
| 1 hour | $3\times10^{-14}$ |
| 1 day | $2\times10^{-14}$ |
| 1 month | $3\times10^{-13}$ |
| Resettability | $\pm5\times10^{-13}$ |

A program is underway to reduce the size of the unit to approximately a half. Investigations are being carried out with a spherical quartz dielectric cavity. This cavity is considerably smaller than the cylindrical cavity now used and would allow a substantial reduction in the size of the magnetic and thermal shields.

**Notes:**

1. Because of its excellent short- and long-term frequency stability, the hydrogen maser would be useful for laboratory time-frequency measurements and spectroscopy, as well as a ground-based frequency reference for precision tracking systems. In space it could be used in geodetic research, navigation, time distribution, and in important physical measurements such as on the relativistic gravitational red shift.
2. Inquiries concerning this innovation may be directed to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B67-10146

**Patent status:**

No patent action is contemplated by NASA.

Source: Robert Vessot and Jacques Vanier
of Varian Associates
under contract to
Marshall Space Flight Center
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